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In vitro gas production, rumen parameters and nutrients degradability of diets based on *Cenchrus ciliaris* grass-shrubs and tree leaves in sheep and goat

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In present study diets based on *Cenchrus ciliaris*–shrubs/ tree leaves in 50:50 and 75:25 ratios were evaluated for *in vitro* gas production, nutrients degradation and metabolites production in inoculums of sheep and goat with the objective to optimize the grass: shrubs/tree leaves proportion in silvi-pasture system for sheep and goat.

Sample collection, processing and dietary preparations

Cenchrus ciliaris-CC grass, tree leaves (*Hardwickia binata*-HB, *Albizia lebbek*-AL, *Grewia optiva*-GO, *Anogeissus pendulla*-AP and *Leucaena leucocephala*-LL) and shrubs (*Dichrostachys cineria*-DC, *Securengia virosa*-SV, *Zizyphus xylophyrus*-ZX, *Helictris isora*-HI *and Acacia catechu*-AC) based on their relative yield potential, availability and use in feeding systems in Bundelkhand region were collected from the grazing fields and nursery of Crop Improvement and Grassland and Silvipastoral Division of Institute.

The samples of grass, tree leaves and shrubs were initially dried in shade followed by drying in hot air oven at 60–65°C till a constant weight is achieved. The dried samples were ground through 1 mm sieve. Ground samples were used for preparation of 20 diets using CC-individual shrub and tree leaves in 50:50 and 75:25 proportions.

Analytical techniques

Dietary combinations of CC- shrub/tree leaves were analyzed for proximate constituents (AOAC 1980) and cell wall fractions (NDF, ADF, cellulose and lignin) as per Goering and Van Soest (1970). Gas production and DM degradability due to fermentation of grass: shrubs and tree leaves diets in inoculums of sheep and goat were estimated following technique of Theodorou *et al.* (1994). For fermentation pattern, 0.5g samples of CC- tree leaves and shrubs diets (50:50 and 75:25 ratios) in triplicate were incubated in sheep and goat inoculum for 48 h using first stage of in *vitro* technique (Tilley and Terry 1963). After 48h of incubation, the samples were filtered through sintered crucible and filtrate was analyzed for total nitrogen and ammonia-nitrogen and TVFA as per McKenzie and Wallace (1954), Conway *et al.* (1951) and Briggs *et al.* (1957), respectively.

Data were analyzed using SPSS 13.0. Duncan's multiple range test was applied for comparison of means within group.

CC- shrubs/tree leaves diets varied significantly ($P<0.05$) in OM, CP, NDF and lignin contents (Table 1). The dietary regimes of CC with LL, AL (11.10 and 8.50) and GO at 50: 50 and 75:25 proportions were higher in CP. Mean NDF and cellulose varied across the dietary combinations of CC-shrubs/tree leaves. Mean ADF contents were highest ($P<0.05$) in CC-AL against lowest in CC-HI, while the concentration of lignin was maximum ($P<0.05$) in CC-DC and lowest in CC-GO dietary combination. The mean contents of CP were higher ($P<0.05$) at 50: 50 than 75:25, while the concentration of NDF, ADF, cellulose and hemicellulose was low at earlier than later ratio of grass- shrubs and tree leaves diets. The variability in chemical constituents of grass-shrubs/tree leaves dietary regimes may be attributed to relative concentration of these nutrients in evaluated shrubs and tree leaves. The variability in CP and fiber fractions in shrubs and tree leaves has been reported (Chaurasia *et al.* 2006).

Gas production kinetics

The mean gas production due to incubation of CC- LL, CC-GO, CC-SV and CC- HI in sheep and goat was higher at initial 3 ,6, 12 and 24 h than other diets of *CC*-shrubs/tree leaves. Incubation of CC–AC, CC-DC, CC-ZX, CC-AP and *CC-HB* exhibited higher gas production in rumen inoculum of sheep and goat at 48 h. Mean gas production was ($P<0.05$) higher at 75:25 ratio at 24, 30 and 48 h of incubation both in sheep and goat than at 50:50 in sheep and goat respectively. Total gas production was higher due to incubation of CC-GO, CC- SV and CC-HI and lowest due to CC- DC, CC-AP and CC-AC in both sheep and goat, respectively (Fig. 1).The

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Table 1. Chemical composition of *Cenchrus ciliaris*- shrubs/tree leaves diets

Dietary combination	OM	CP	NDF	ADF	Cellulose	Hemi-cellulose	Lignin
C. ciliaris+A. catechu 50:50	85.23	8.20	52.90	32.40	23.30	20.50	7.50
C. ciliaris+A. catechu 75:25	89.90	7.00	58.30	35.20	26.60	23.10	7.20
Mean	87.56	7.60	55.60	33.80	24.95	21.80	7.35
C. ciliaris+Z.xylopyrus 50:50	90.60	8.22	52.20	30.40	22.20	21.80	8.20
C. ciliaris+Z.xylopyrus 75:25	90.12	7.00	61.50	37.00	29.30	24.50	7.60
Mean	90.36	7.61	56.85	33.70	25.75	23.15	7.90
C. ciliaris+H. isora 50:50	89.21	7.96	60.64	34.50	26.20	26.14	6.00
C. ciliaris+H. isora 75:25	89.16	6.47	61.68	35.50	26.80	26.18	8.10
Mean	89.18	7.21	61.16	35.00	26.50	26.15	7.05
C. ciliaris+S. virosa 50:50	90.19	7.83	42.50	20.80	21.00	21.70	9.90
C. ciliaris+S. virosa 75:25	88.83	6.65	59.50	35.50	29.50	24.00	5.40
Mean	89.51	7.24	51.00	28.15	25.25	22.85	7.65
C. ciliaris+D. cinerea 50:50	86.90	9.05	55.20	35.00	23.10	20.20	11.00
C. ciliaris+D. cinerea 75:25	87.16	6.81	63.10	38.50	28.70	24.60	8.20
Mean	87.03	7.93	59.15	36.75	25.90	22.40	9.60
C.ciliaris+L.leucocephala 50:50	88.59	13.6	51.41	29.60	21.20	21.81	7.10
C.ciliaris+L.leucocephal 75:25	89.31	9.93	59.00	36.70	24.80	22.30	10.11
Mean	88.95	11.76	55.20	33.15	23.00	22.05	8.60
C. ciliaris+A. lebbek 50:50	90.70	11.1	58.20	37.90	26.90	20.30	9.90
C. ciliaris+A. lebbek 75:25	91.20	8.5	63.30	41.40	32.10	22.30	7.80
Mean	90.95	9.80	60.75	39.65	29.50	21.30	8.85
C. ciliaris+H. binata 50:50	90.00	6.8	55.20	33.50	25.30	21.70	7.40
C. ciliaris+H. binata 75:25	90.62	5.2	61.40	37.90	29.20	23.50	7.50
Mean	90.31	6.00	58.30	35.70	27.25	22.60	7.45
C. ciliaris+A. pendula 50:50	90.52	8.5	51.10	31.50	22.24	19.60	9.70
C. ciliaris+A. pendula 75:25	90.12	6.2	60.70	36.60	28.90	24.10	5.70
Mean	90.32	7.35	55.90	34.05	25.57	21.85	7.70
C. ciliaris+G. optiva 50:50	88.63	10.3	53.60	29.30	23.80	24.30	5.20
C. ciliaris+G. optiva 75:25	88.40	7.7	61.80	33.10	25.10	28.70	4.20
Mean	88.51	9.00	57.70	31.20	24.45	26.50	4.70
Grand mean 50:50	89.05	9.15	53.92	31.49	23.52	21.80	8.19
75:25	89.48	7.14	61.03	36.74	28.10	24.32	7.18
SEm 50:50	0.567	0.31	1.641	1.457	0.643	0.636	0.597
75:25	0.370	.414	0.525	0.706	0.710	0.607	0.531
Ratio	NS	*	*	*	*	*	NS
Diet	*	*	NS		NS	*	*

*Differ significantly at P<0.05; NS, nonsignificant.

variability in gas production of grass-tree leaves/shrubs diets may be explained by variability in non-structural polysaccharides contents particularly the starch (Chaurasia *et al.* 2006). Fermentable carbohydrates increase gas production and degradable nitrogen compounds decrease gas production to some extent because of the binding of carbon dioxide to ammonia (Krishanamoorthy *et al.* 1995). Mean gas production due to incubation of CC and shrubs/tree leaves was (P0.05) higher in sheep and goat at their 75:25 ratio than at 50:50 (Fig. 2). This may be attributed to availability of more structural carbohydrates supplied through higher proportion of grass component in mixed diet.

Nutrients degradability

DM degradability was (P<0.05) higher on CC-SV, CC-HI and CC-GO diets in sheep, while in goat inoculum CC-SV and CC-GO were more degradable (Table 2). Conversely, CC-DC and CC-AC diets revealed lowest (P<0.05) DM degradability in sheep vis-à-vis goat at their 50:50 and 75:25 ratios, respectively. CP degradability was more (P<0.05) due to fermentation of CC-LL, CC- GO and CC-AP and CC-SV both in sheep and goat compared to lower on CC-AC and CC-DC in sheep and goat. Mean degradability of NDF and ADF was higher (P<0.05) on CC-HI, CC-LL, CC-GO and CC-AP in rumen inoculum of sheep and goat. Degradability of NDF and ADF was lower on CC- AC, CC-DC and CC-HB both in sheep and goat.The mean degradability of DM, CP, NDF and ADF indicated higher degradability of DM, NDF and ADF in at 75:25 and 50:50 ratio in sheep and goat, respectively.

Table 2. Nutrients degradability (%) of *Cenchrus ciliaris*- tree leaves/shrubs diets in sheep and goat inoculums

Dietary ratio	Sheep				Goat			
	DM	CP	NDF	ADF	DM	CP	NDF	ADF
CC: AC 50: 50	59.1	53.40	41.30	32.80	63.2	51.7	49.2	42.10
CC: AC 75: 25	62.6	56.40	46.20	42.10	62.8	54.3	46.7	41.80
Mean	60.8	54.90	43.75	37.45	63.0	53.00	47.95	41.95
CC: ZX 50: 50	63.6	60.30	44.30	40.80	62.4	63.2	47.0	43.60
CC: ZX 75: 25	63.4	57.80	50.80	46.30	57.9	59.7	41.8	37.00
Mean	63.5	59.05	47.55	43.30	60.2	61.45	44.40	40.30
CC: HI 50: 50	70.4	56.40	50.50	45.00	64.3	59.10	53.2	44.40
CC: HI 75: 25	65.9	52.10	61.30	56.90	63.1	57.00	50.6	41.00
Mean	68.1	54.25	55.90	50.95	63.7	58.05	51.90	42.70
CC: SV 50: 50	72.0	71.20	56.90	43.70	67.9	73.90	56.5	53.30
CC: SV 75: 25	65.7	65.20	47.00	44.00	68.5	66.70	44.0	39.00
Mean	66.5	68.20	51.95	43.85	68.2	70.30	50.2	46.15
CC: DC 50: 50	51.5	48.10	36.30	30.20	55.5	52.30	44.70	40.10
CC: DC 75: 25	59.8	51.90	40.00	32.30	62.5	54.20	46.30	42.30
Mean	55.5	50.00	38.35	31.25	59.0	53.25	45.50	41.20
CC: LL 50: 50	65.1	77.12	47.00	35.60	67.9	77.00	57.70	47.70
CC: LL 75: 25	64.4	73.80	54.00	52.00	61.9	69.40	40.80	37.90
Mean	64.7	75.46	50.50	43.80	64.9	73.20	50.25	42.80
CC: AL 50: 50	64.5	73.20	48.10	41.10	62.9	72.10	50.10	42.70
CC: AL 75: 25	66.8	64.30	53.10	50.20	65.7	66.10	51.30	47.10
Mean	65.7	68.75	50.60	45.65	64.3	69.10	50.70	44.90
CC: HB 50: 50	60.5	56.20	48.70	40.30	63.1	58.20	49.20	43.70
CC: HB 75: 25	66.1	63.10	53.30	48.70	63.2	62.40	51.70	46.50
Mean	63.3	59.65	51.00	44.50	63.1	60.30	50.45	45.10
CC:AP 50: 50	64.0	66.10	52.30	46.60	60.0	64.00	56.10	45.20
CC:AP 75: 25	68.1	72.50	56.80	51.40	66.2	72.40	53.50	42.80
Mean	66.0	69.30	54.55	49.00	63.2	68.20	54.80	44.00
CC: GO 50: 50	69.9.	70.60	59.20	54.10	73.3	72.60	62.90	59.80
CC: GO 75: 25	72.3	68.70	63.70	54.40	68.2	70.20	57.10	52.60
Mean	70.08	69.65	61.45	54.25	70.7	71.40	60.00	56.20
Grand mean 50: 50	64.60	63.26	48.46	40.97	63.61	64.41	52.66	46.26
75: 25	64.91	62.58	52.66	47.83	62.86	58.04	48.38	42.80
SEm 50: 50	1.231	3.071	2.171	2.211	1.226	2.889	1.773	1.89
75: 25	0.670	2.487	2.220	2.243	0.784	6.224	1.679	1.508
Ratio	NS	NS	NS	*	NS	NS	*	NS
Diet	*	*	*	*	*	*	*	*

*Differ significantly at $P<0.05$; NS, nonsignificant.

Accumulation of tannins and phenols in tree leaves and shrubs has been reported earlier (Ahn *et al.* 1989, Kumar and Singh 1988) might be responsible for the differences in the nutrients degradability of grass-shrubs/tree leaves diets. The variability in the nutrients degradability between sheep and goat (Larbi *et al.* 1997) and among poor quality feeds supplemented with grade levels of tree leaves/shrubs in ruminants have been reported (Bosma and Bicaba 1997). The DM digestibility in the range of 57–62.1, 48.8–56.4 and 60.9–64.1% in goats fed barley straw as basal feed with varying levels of *L. leucocephala, A. chinensis* and *S. sesban*, respectively (Norton *et al.* 1992) are on the line of present observations.

Fermentation pattern

Mean concentration of total-N and NH_3–N varied ($P<0.05$) due to fermentation of *CC*-shrubs/tree leaves diets in inoculum of sheep and goat (Table 3). Total-N and NH_3–N were higher ($P<0.05$) due to incubation of *CC-LL, CC-SV* and *CC-HI* in rumen inoculum of sheep and goat. Conversely fermentation of *CC-HB, CC-DC* and CC-AC resulted in lower total-N and NH_3–N production in rumen inoculum of sheep and goat. Total volatile fatty acids production was identical in both ratios (50:50 and 75:25) due to incubation of *CC* with shrubs/tree leaves in rumen inoculum of sheep and goat. However, the total-N and NH_3–N production was significantly ($P<0.05$) higher at 50:50 in sheep and goat than

Table 3. Rumen metabolites concentration on incubation of *Cenchrus ciliaris*- tree leaves/shrubs diets in sheep and goat inoculums

Dietary ratio	Sheep			Goat		
	TVFA	Total-N	NH3-N	TVFA	Total-N	NH3-N
CC: AC 50: 50	56.2	44.8	8.4	55.0	50.4	11.2
CC: AC 75: 25	62.5	44.8	9.8	49.0	39.2	9.1
Mean	59.35	44.80	9.10	52.00	44.80	10.15
CC: ZX 50: 50	61.0	44.8	9.8	50.0	50.4	9.1
CC: ZX 75: 25	70.5	40.4	8.4	68.0	42.0	8.4
Mean	65.75	42.60	9.10	59.00	46.20	8.75
CC: HI 50: 50	73.0	53.2	11.9	81.0	50.4	12.6
CC: HI 75: 25	72.0	47.6	9.1	79.0	47.6	9.1
Mean	72.50	50.40	10.50	80.00	49.00	10.85
CC: SV 50: 50	88.0	56.0	12.6	104.0	58.8	14.7
CC: SV 75: 25	73.0	47.6	9.6	102.0	47.6	9.1
Mean	80.50	50.80	11.10	103.00	53.20	11.90
CC: DC 50: 50	65.0	44.8	9.8	76.0	42.0	9.1
CC: DC 75: 25	68.0	36.4	8.4	62.0	39.2	7.0
Mean	66.50	40.60	9.10	69.00	40.60	8.05
CC: LL 50: 50	105.0	58.8	14.0	110.0	61.6	14.0
CC: LL 75: 25	65.0	42.0	10.5	94.0	47.6	11.9
Mean	85.00	50.40	12.25	102.00	54.60	12.95
CC: AL 50: 50	67.0	50.4	11.2	70.0	44.8	12.6
CC: Al 75: 25	73.0	44.8	9.1	63.0	33.6	9.8
Mean	70.00	47.60	10.15	66.50	39.20	11.20
CC: HB 50: 50	58.0	39.2	9.8	71.0	39.2	9.8
CC: HB 75: 25	67.0	33.6	9.8	68.0	33.6	7.7
Mean	62.50	36.40	9.8	69.50	36.40	8.75
CC: AP 50: 50	76.0	50.4	8.4	80.0	47.6	11.9
CC: AP 75: 25	94.0	42.0	8.4	65.0	42.0	9.8
Mean	85.00	46.20	8.40	72.50	44.80	10.85
CC: GO 50: 50	87.0	50.4	14.7	68.0	53.2	14.0
CC: GO 75: 25	74.0	44.8	11.2	82.0	44.8	11.2
Mean	80.50	47.60	12.95	75.00	49.00	12.60
Grand Mean 50: 50	73.62	49.28	11.06	76.50	49.84	11.90
75: 25	71.90	42.40	9.43	73.20	41.72	9.31
Sem 50: 50	4.945	1.876	0.698	5.982	2.200	0.652
75: 25	2.733	1.450	0.298	5.065	1.693	0.467
Ratio	NS	*	*	NS	*	*
Diet	NS	*	*	*	*	NS

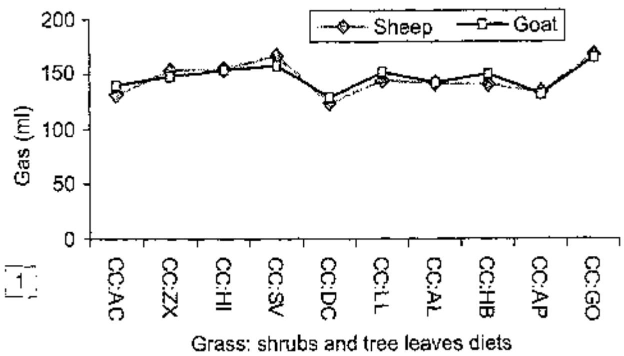
* Differ significantly at P<0.05; NS, nonsignificant.

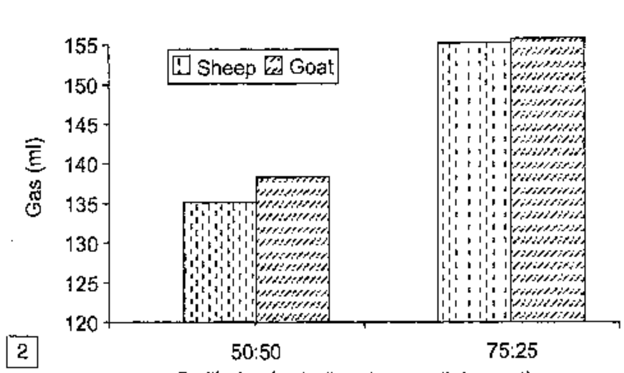
at 75: 25 ratio of *CC* with shrubs/tree leaves.

Variations observed in concentration of TVFA and N metabolites of *CC*-shrubs/tree leaves diets in the present study may be attributed to nutrients concentration (CP, NDF and ADF) and their degradability. Higher N metabolites production at 50:50 ratio of *CC* -shrubs and tree leaves diets in inoculum of sheep and goat may partly be explained by higher proportion of shrubs/tree leaves. Further the relative concentration and chemical make up of tannins and phenols present in shrubs and tree leaves have inhibited the fermentation of protein and carbohydrates (Woodward and Reid 1989, Kibon and Orskov 1993) resulting lower production of rumen metabolites. Increased level of ammonia-N due to supplementation of maize stover with graded levels of *Leucaena* and *Gliricidia* in steers has been demonstrated (Abdulrazak *et al.* 1997). Higher concentration of NH_3–N and TVFA from *A. nilotica* and *S sesban* than *A. seyal* supplemented straw diet in goats and sheep has been recorded (Ebong 1995).

SUMMARY

Twenty dietary combination of *Cenchrus ciliaris-CC* grass with shrubs (*Dichrostachys cineria-DC Securengia virosa-SV, Zizyphus xylophyrus-ZX, Helictris isora-HI* and





Figs 1–2. **1.** Mean total gas production (ml) due to incubation of *C ciliaris* grass with shrubs and tree leaves at 50:50 and 75:25 ratios in sheep and goat inoculums. **2.**Mean gas production due to incubation of *C. ciliaris* with shrubs and tree leaves at 50:50 and 75:25 ration in sheep and goat inoculums

Acacia catechu-AC) and tree leaves (*Hardwickia binata-HB, Albizia lebbek-AL, Grewia optiva-GO, Anogessus pendulla-AP* and *Leucaena leucocephala-LL*) in 50:50 and 75:25 ratios were evaluated for *in vitro* gas production, nutrients degradation and metabolites production in sheep and goat inoculums.

The results showed that dietary combinations of *CC* with *SV, HI, LL* and *GO* at both ratios had higher gas production, more nutrients degradability and higher metabolites production. Sheep and goat had more nutrients degradability and higher metabolites production at 75:25 and 50:50 ratios of *CC* with shrubs/tree leaves, respectively. Thus for development of silvipasture system for sheep and goat its biomass should constitute grass and shrubs/tree leaves in 75:25 and 50:50 ratios respectively.

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